ASSESSING EFFECTIVENESS IN SIMULATION TRAINING
Marksmanship Training Simulation as an Experimental Test Bed

EXCERPTS

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July 2010

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Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **JUL 2010**	2. REPORT TYPE	3. DATES COVERED **00-00-2010 to 00-00-2010**
4. TITLE AND SUBTITLE **Assessing Effectiveness in Simulation Training. Marksmanship Training Simulation as an Experimental Test Bed**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Postgraduate School,Moves Institute,Monterey,CA,93943**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**33**	

Human Performance Assessment In Training

Instructional Method

Learning Domains

- Cognitive – Intellectual skills (facts, procedures, concepts, rules, principles)
- Psychomotor – complex perceptual – motor skills
- Affective – emotional control, stress – coping, attitudinal predisposition to respond

Learning Stages for Complex Cognitive Skills:

Relevant Strategy

1. **Novice** – Rigid adherence to rules; poor situational perception; no experience
2. **Advanced beginner** – uses guidelines for action, still limited situational perception
3. **Competent** – better view of big picture; plans ahead; but still procedure driven.
4. **Proficient** – holistic view and able to extract most important elements of situation; uses maxims (generalizable)
5. **Expert** – no longer relies on rules, guidelines or maxims; intuitive grasp and recognition of patterns for ease of decision action.

Dryfus & Dryfus (1980)

Learning Stages For Complex Perceptual Motor Learning

Relevant Strategy

- Cognitive – knowledge based (thinking, verbal) understanding of task and strategies
- Associative – procedural (rule-based) understanding of steps or task sequence
- Autonomous –(unconscious) automatic execution of skilled performance with high accuracy and precision

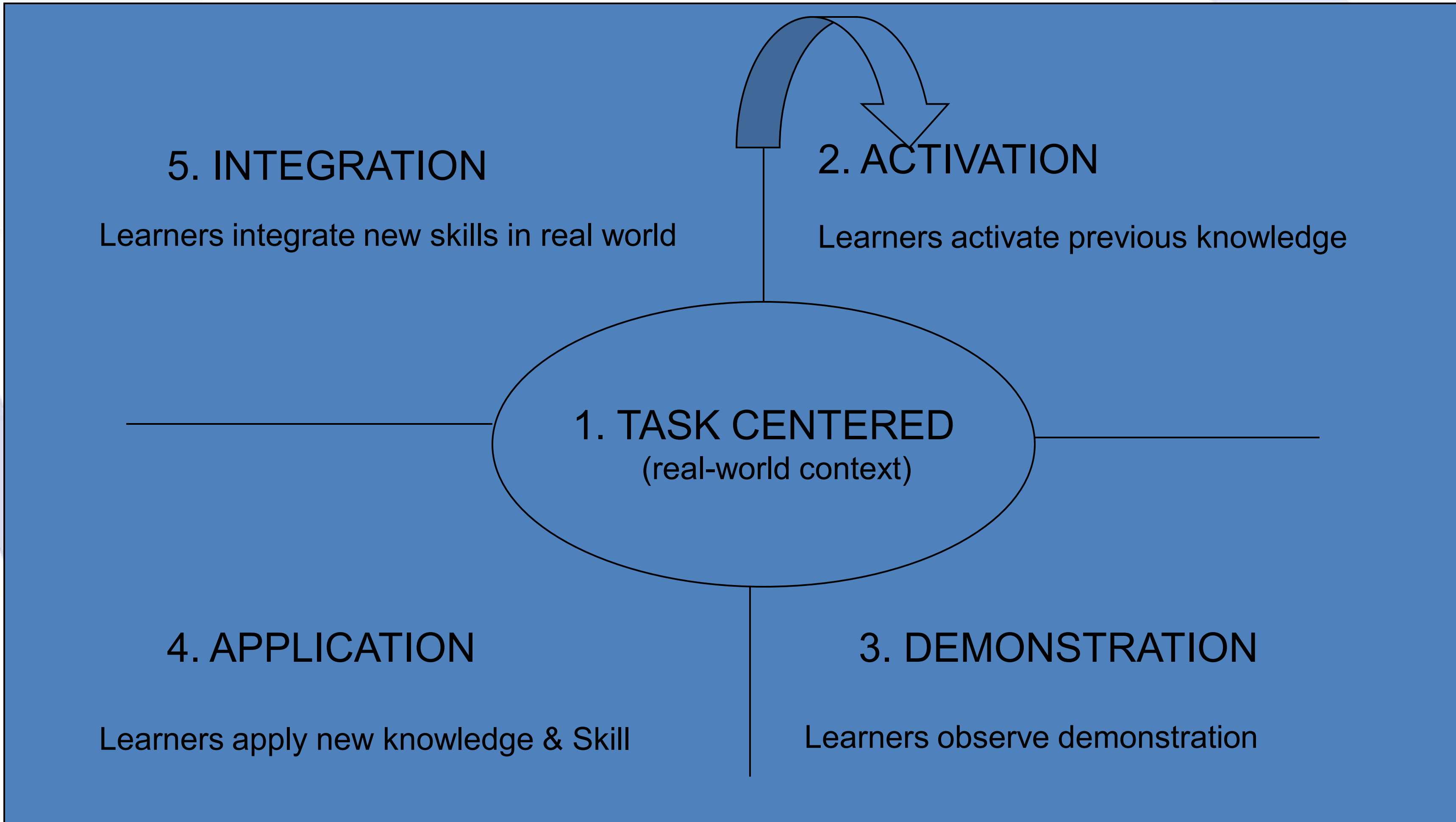
Fitts and Posner (1967)

Skill Acquisition Theories

Ackerman

- Patterns of correlation coefficients between cognitive knowledge and perceptual motor performance change substantially over the course of training.
- Ackerman (2007) gives the following reason for this finding.
- Cognitive aspects of the task are more influential during early skill learning – so perceptual-motor components have greater influence as learning progresses

First Principles of Instruction



(Merrill 2007)

Instructional Strategies for Complex Perceptual Motor Training

- **Teaching Strategies for Associative Phase**

- Provide the learner an opportunity to practice the procedure (with coaching and feedback).
- Test student at completion of practice trials at appropriate level of performance defined in the learning objectives.
- Complex tasks can be broken down into key components for deliberate practice.

- **Teaching Strategies for the Autonomous Phase**
-
- 1. Continue deliberate practice on the more difficult task components.
- 2. Increase the speed of response and task difficulty progression. (Challenge the learner.)

Selection of an incorrect strategy can impact learning effectiveness.

Instructional Strategies

These strategies are based upon teaching experience and are supported by skill acquisition studies:

- Provide students with tutorial information regarding the task structure and salient cues to pay attention to, at the start of instruction – but reduce or eliminate later.
- Demonstrate correct performance to student, showing correct response sequence and timing.
- Reinforce attention to salient cues during practice sessions, and provide feedback of performance results.
- As skill becomes more automated, provide less coaching and verbal support during task performance

After Action Performance Feedback

- Fully integrated (with a training system), or a strap-on automated performance system, that records performance, reconstructs and plays back training sessions.
- Task-based diagnostic assessment and highlighting of key mission events, providing immediate post-mission feedback of training results, and for evaluation of training effectiveness.
  - Diagnostic (corrective) feedback indexed to key training scenarios and learning objectives
  - Cumulative performance data for tactics development and for estimating combat readiness, and training effectiveness

Evaluation of Training

Kirkpatrick's Model

- LEVEL 1- Reaction (attitude – opinion)
- **LEVEL 2 – Learning (achievement test)**
- LEVEL 3 – Behavior (job performance)
- LEVEL 4 – Results (effectiveness - impact)

End of Course evaluation

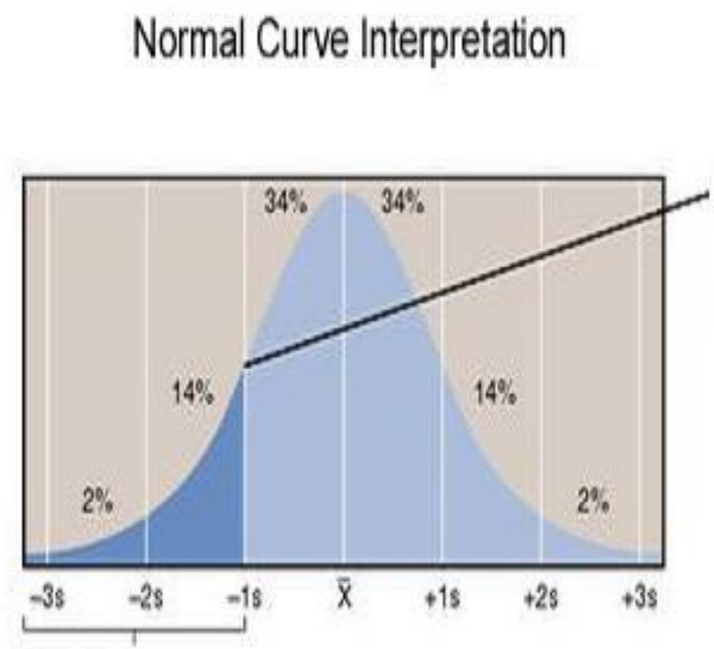
- Used to determine whether or not student has mastered course learning objectives.
- Typically measured by achievement test, based on specified knowledge and skills
- Objective tests – usually written exams can be norm-based or criterion based

Types of tests

- Norm-based – most common form, puts all students on “normal distribution” using class average, or some other form of comparative scale for distribution scoring.

- Criterion-based – uses percent completion or mastery of specific learning objectives per student against preset e 80

Placement of a specific rating on Normal Distribution Curve



Rating is 1 standard deviation below mean

Rating is in 14^{th} percentile
86% of ratings are above this one

Measurement Issues

- Internal and External Experimental validity
  - Internal validity: did treatment (training) make the difference
  - External validity: will this treatment work in other similar applications (generalizability of results)
- Measurement Reliability – dependable, error free measures (acceptable performance variability)
- Measurement Validity – do measures make sense for intended purpose. Are we measuring the right thing and correctly interpreting measures used.

Cognitive Performance

- Classroom exams – objective and essay
- Academic Laboratory exams
- Simulation and Game Exercises
- Problem Solving projects (teamwork)

Perceptual-motor performance

- Reaction times
- Response rates
- Accuracy
- Precision (performance variation)
- Errors and deviations from a criterion

Complex perceptual motor
Common measures

- Time history
  - Time on target
  - Accuracy and precision transforms
  - Time out of tolerance
  - Percent time in tolerance
  - Response or reaction time
  - Tracking deviations (overshoot undershoot)
- Amplitude distribution
  - Mean, median, mode
  - Standard deviation, variance, range
  - Minimum/maximum value
  - Root-mean-squared error
  - Absolute average error
- Frequency domain
  - Power spectral density function
  - Bandwidth, peak power, low-high frequency
  - Wave form and other Transfer functions
- Binary
  - Switch activation sequence (right –wrong)
  - Procedure completion, (omission, commission errors)

(Vreuls and Wooldridge, 1977)

METRICS - RMS

Way of calculating the root mean square

The RMS of a collection of *n* values

$$x_{\mathrm{rms}} = \sqrt{\langle x^2 \rangle} \; \{x_1, x_2, \ldots, x_n\}$$

$$x_{\mathrm{rms}} = \sqrt{\frac{1}{n}\sum_{i=1}^{n} x_i^2} = \sqrt{\frac{x_1^2 + x_2^2 + \cdots + x_n^2}{n}}$$

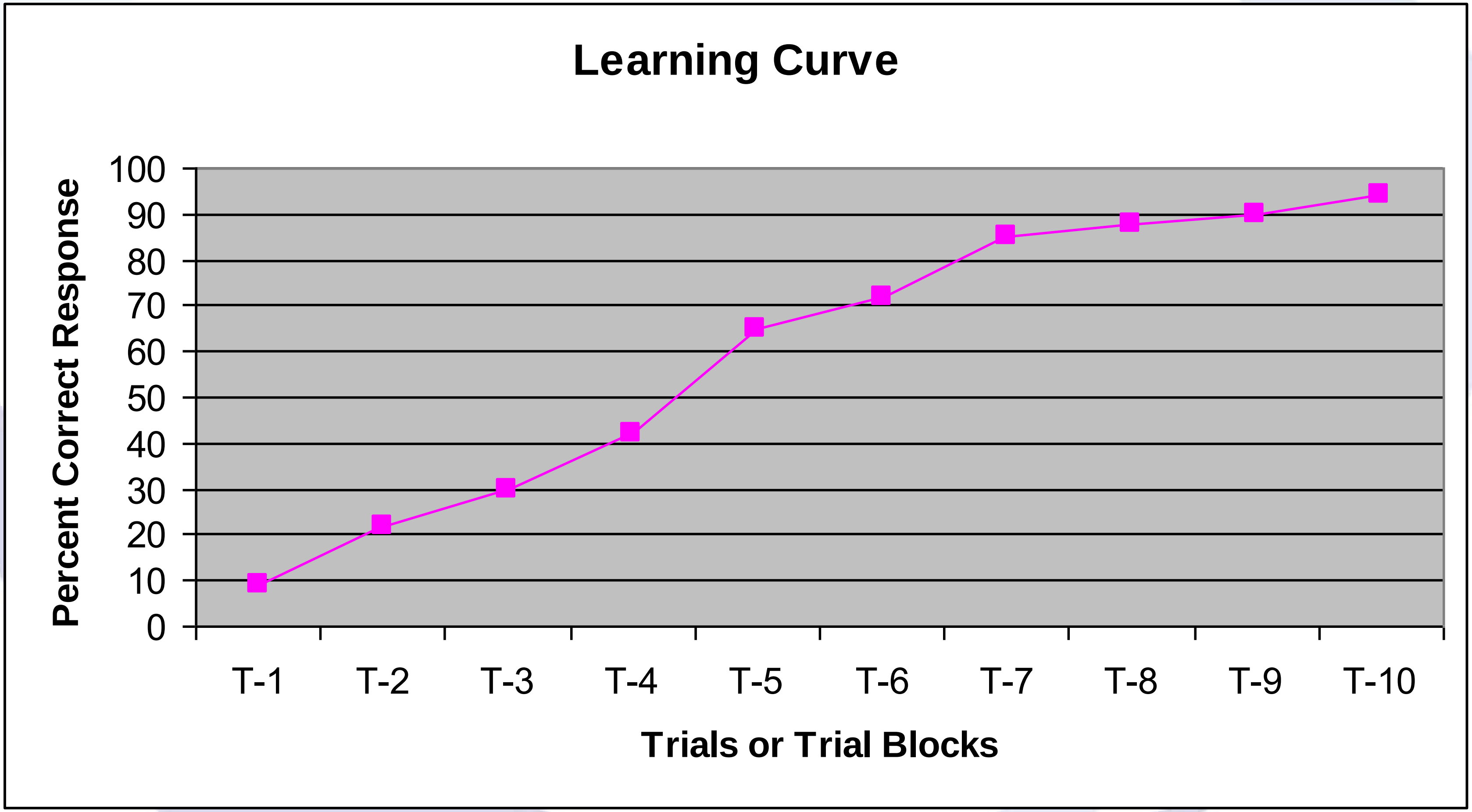
Th

$$T_1 \le t \le T_2$$

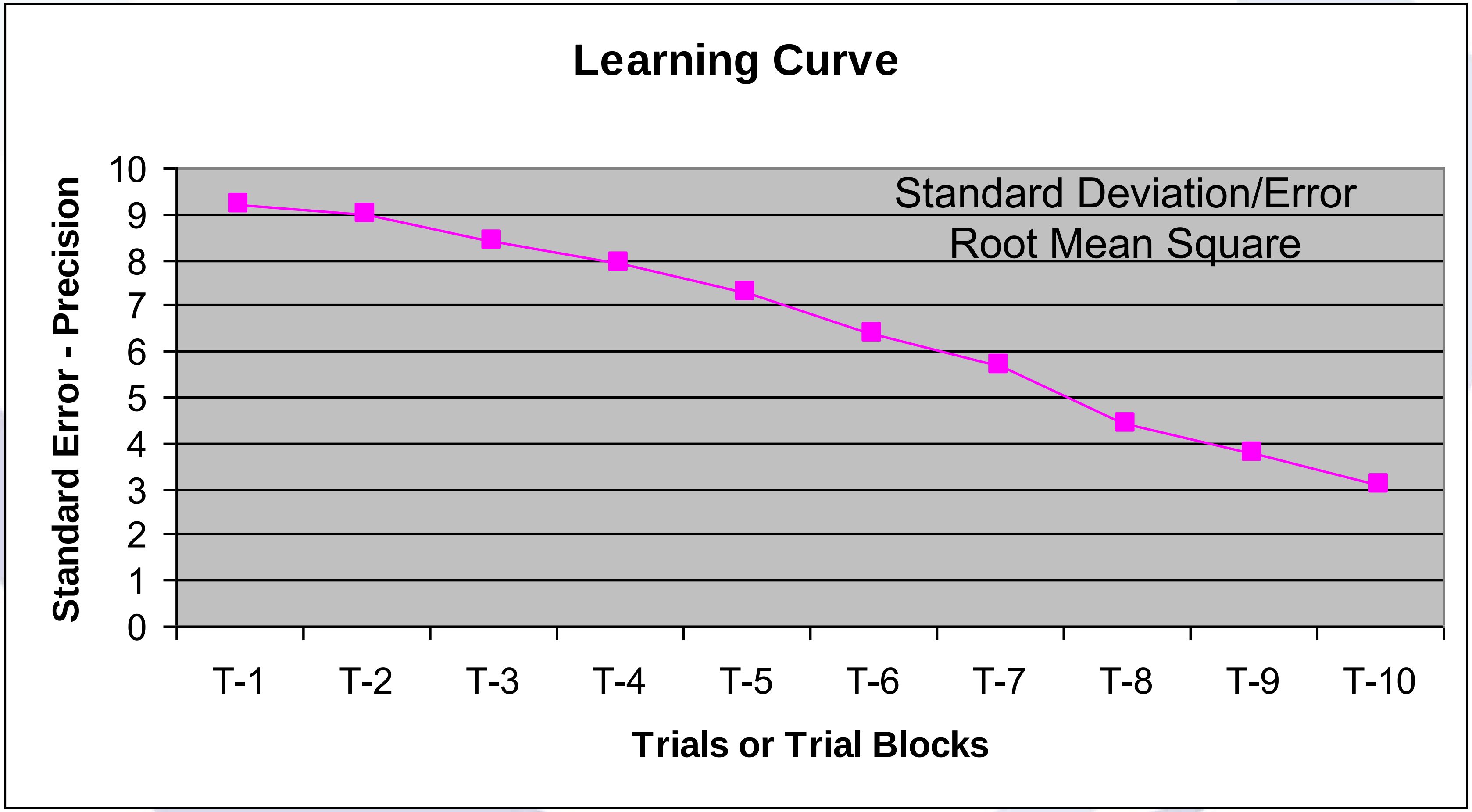
$$f_{\mathrm{rms}} = \sqrt{\frac{1}{T_2 - T_1}\int_{T_1}^{T_2} [f(t)]^2 \, dt}$$

The RMS of a periodic function is equal to the RMS of one period of the function. The RMS value of a continuous function or signal can be approximated by taking the RMS of a series of equally spaced samples

Basic Skill Acquisition Progress



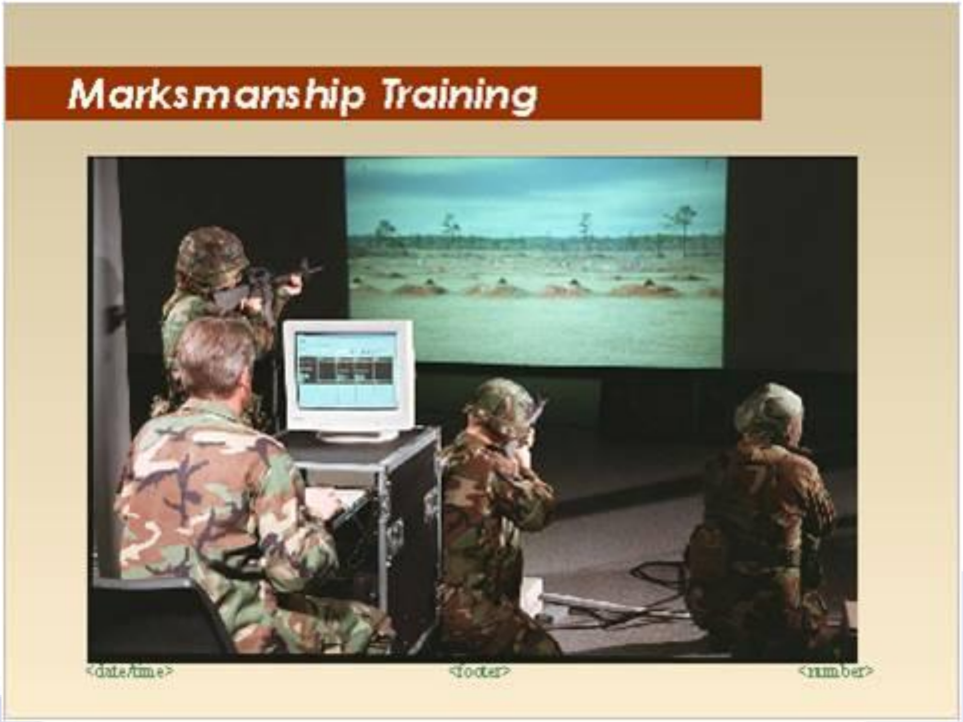
Basic Skill Acquisition Progress Measures of Precision



Marksmanship Skill Application

- The US Army and USMC define expert marksmanship as hitting 36 or more targets out of 40 on a pop-up target live firing range. (FM 3-22.9 Rifle Marksmanship, 2008; Marine Corps, 2001)
- Basic Marksmanship Skills -- The Army and Marine Corps define and train to five basic skill components of rifle marksmanship:
- **1. Trigger pull, 2.breathing, 3.butt stock pressure, 4.weapon cant, and 5.consistent (stabile) aiming point.**
- An exploratory study, using motion capture technology, was conducted by our graduate students US Army officers, Majors William Platte and Johnny Powers. The purpose was to measure shooting postural performance as a fundamental shooting skill -- in order to objectively determine a shooter’s skill level, or overall expertise, and possibly to provide a diagnostic assessment and feedback method.

Engagement Skills Trainer (EST)



EST After Action Review: Scoring Accuracy: Outcome Metrics

Marksmanship Skill
Example – Correct Prone Position

The prone position provides a very steady foundation for shooting and presents a low profile for maximum concealment. However, the prone position is the least mobile of the shooting positions and may restrict a Marine's field of view for observation. In this position, the Marine's weight is evenly distributed on the elbows, providing maximum support and good stability for the rifle.

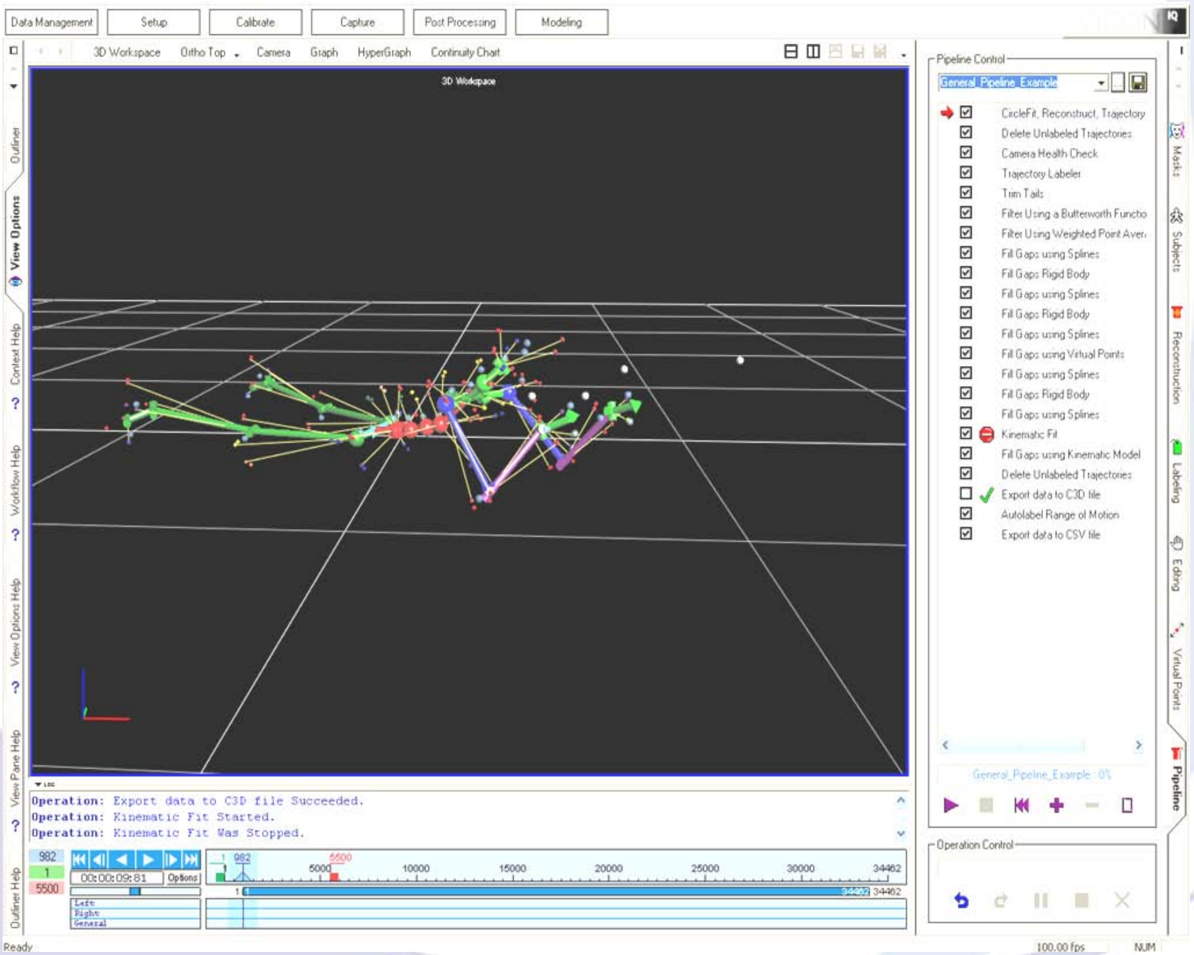
MCRP 3-01A

Individual Performance Measures (Cognitive - Marksmanship)

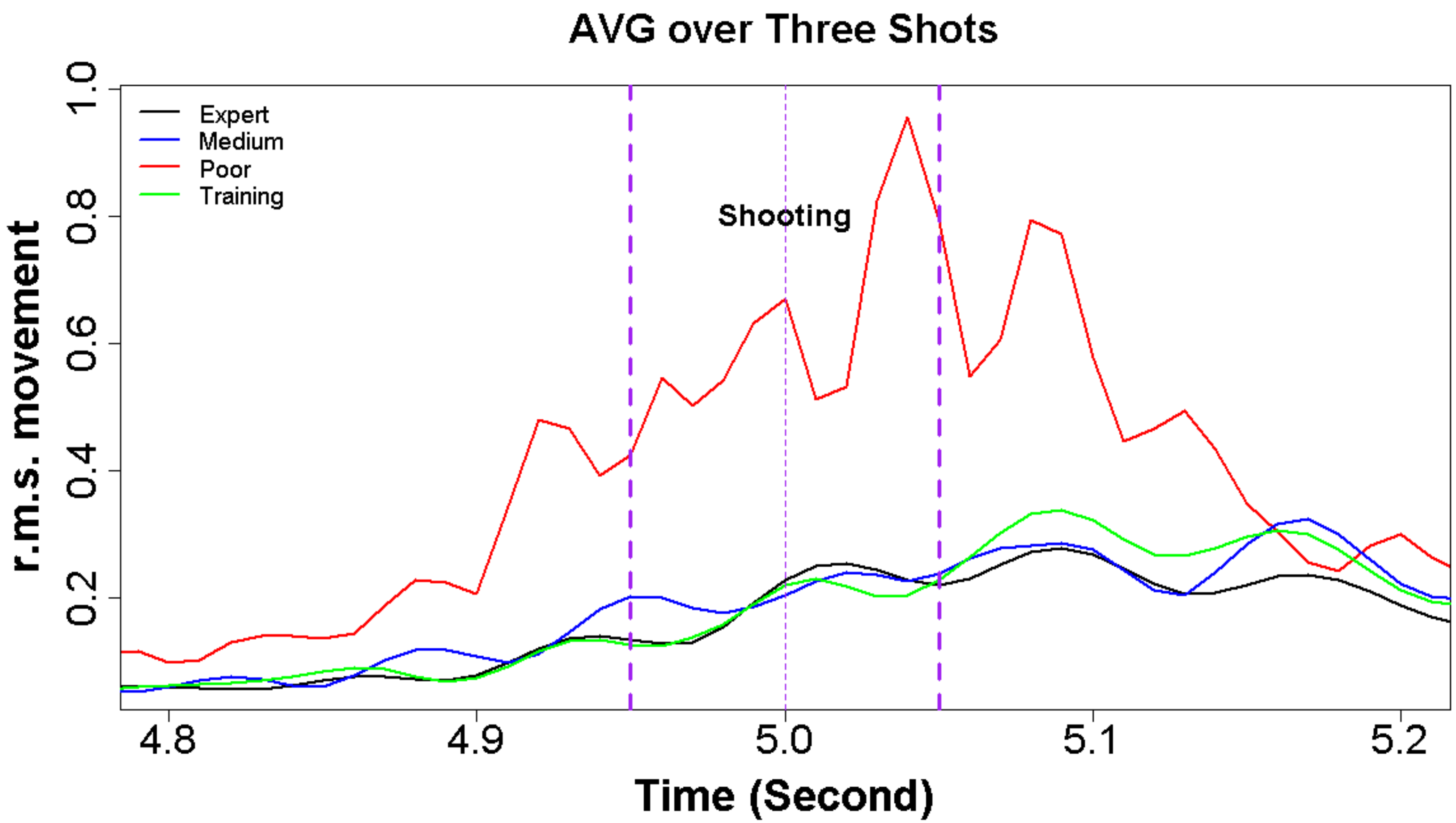
- Explain concept of firing accuracy (gun sight calibration, aiming and recoil control)
- Show instructor correct aiming and stock-weld procedure.
- Explain how correct - incorrect breath control affects accuracy.
- Explain the effects of wind and distance on bullet trajectory
- Replay – critical review to assess the quality of tactical decisions, and specific decision errors

Motion Capture: Postural Accuracy Skill Process Metric

Experimental Results – SANTOS tm Post Processing



MOCAP RESULTS
Statistical Analysis



Average of Three Shots.

Conclusions and Recommendations

- We are attempting to define and validate instructional strategies and human performance assessment methods for complex skill training, using instrumented marksmanship training as an experimental test bed.
- In this phase of our study, we defined instructional strategies that distinguish cognitive from perceptual motor teaching approaches, with the aim of providing improved instruction in a variety of complex perceptual motor tasks
- Based on human performance research findings from the literature we helped clarify the use of different forms of feedback that are applicable to various stages of learning complex skills.
- We sought to examine new forms of instrumentation (like motion capture) that may provide “process oriented” skill metrics for skill assessment and diagnostic feedback.
- During our next phases of research we will be addressing issues related to marksmanship training in more immersive environments that include realistic interactive scenarios (such as engaging moving targets, decision making and combat team tactics) . The next Phase of research also will identify empirical and non – empirical training effectiveness evaluation methods and analysis templates.

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